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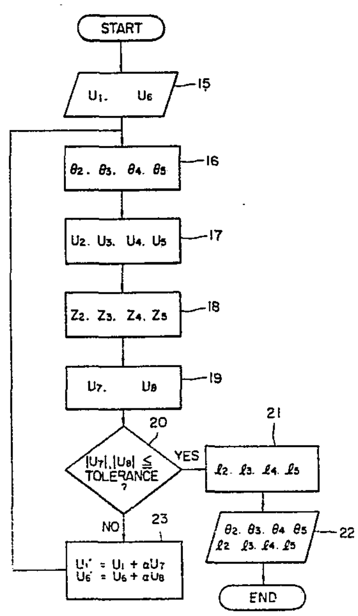
(54) **Method of correcting unbalance of a rotating body.**

(57) In a method of correcting the unbalance of a rotating body (Fig. 5, R), data relating to initial unbalanced amounts or weights (U1, U6) at two predetermined correcting planes axially spaced and passing through the body is processed to determine correcting positions (2 to 5) and corrective machining weights (u2 to u5). The correcting positions and corrective machining weights are used for calculating the location of each center of gravity of each corrective machining portion and residual unbalanced amounts (U7, U8) in the axial direction on the assumption that corrective machining has been effected. The value of each of the residual unbalanced amounts will be compared with a predetermined value corresponding to its tolerance. If the value exceeds the tolerance, new initial unbalanced amounts or new correcting planes are assumed so that the new data will be converted into new initial information (U1', U6'; Fig. 11, U''(Z1'), U''(Z6')) to be fed back to the original step (16) of processing the initial unbalanced amounts. By repeating the operating processes (16 to 23) the residual unbalanced amounts will be within the tolerance so that accurate corrective machining can be effected, balancing the rotating body with a one-time machining.



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TITLE OF THE INVENTION

METHOD OF CORRECTING UNBALANCE OF A ROTATING BODY

BACKGROUND OF THE INVENTION

This invention relates generally to a method of correcting unbalance in a rotating body, such as a rotor of an electrical motor or the like, and more particularly the present invention relates to such a method in which holes or grooves are made in the rotating body by feeding a drill or a milling cutter in a direction parallel to the axis of the rotating body.

As a conventional method of determining or modifying the corrective amount(s) or weigth(s) in view of a measured unbalanced values, a method of making a hole or holes in a radial direction of a rotating body is known. However, since the depth of dril cutting is not proportional to the corrective amount achieved thereby, the corrective amount has to be corrected or modified by some measures.

Some motor rotors have a structure which does not suite for making holes in its radial direction because of its laminated core. In such a case, although it is necessary to correct unbalance by machining the rotor with a milling cutter or drill fed in a direction parallel to the axis of the rotor, residual unbalance is apt to occur due to the deviation of ceter of gravity of the removing weight from each correcting plane. The occurrence of such residual unbalance is known as a correcting plane error.

Since the correcting plane error affects not only the corrective amount of the plane but also the other correcting plane which is located in the vicinity of the other end of the rotor, recorrection of the corrective amounts at both the correcting planes have been thought impossible.

In the conventional techniques, in order to avoid such errors, the corrective machining length in the direction of the axis is made as small as possible or a milling machining method has been adopted for putting the center of gravity of the removing weight at the same position all the time.

In the case that the distance between two correcting planes is very small, the ratio between the unbalanced amount after correction and initial unbalanced amount is only 1/2 to 1/4. Therefore, in order to obtain necessary dynamic balance it has been necessary hitherto to repeat measurments and corrections several times in either case of automatic correction or manual correction. For this reason, the conventional method for obtaning balance of a rotating body has suffered from a problem that it takes a long time and that the working cost and balancing equipment cost are high.

SUMMARY OF THE INVENTION

The present invention has been achived in order to remove the above-mentioned disadvantages and drawbacks inherent to the conventional method of correcting the dynamic unbalance in a rotating body.

It is, therefore, an object of the preent invention to provide a method of correcting the dynamic unbalance of a rotating body so that dynamic balance can be obtained with a one-time machining, reducing the working cost and balacing equipment cost.

According to the feature of the present invention, initial unbalanced amount information or data is processed in a computer so that necessary corrective machining data will be obtained by performing simulation.

In accordance with the feature of the present invention there is provided a method of correcting the dynamic unbalance of a rotating body by either adding or subtracting corrective amounts in the axial direction of said rotating body having an unbalanced amount with respect to its axis, comprising: a first step of determining correcting positions and corrective machining weights in accordance with information ralating to initial unbalanced amounts at two predetermined correcting planes which are axially spaced and passing through said rotating body; a second step of calculating the position of center of gravity of each corrective machining portion on the assumption that corrective machining of said rotating body is effected in accordance with said correcting positions and said corective machining weights; a third step of calculating residual unbalanced amounts, which are located in said axial direction, from said correcting positions and said corrective machining weights; a fourth step of judging whether one or both of said residual unbalanced amounts is within a given range or not; a fifth step of calculating machining amounts corresponding to said unbalanced amounts in the case that one or both of said residual unbalanced amounts has been detected to be within said given range in said fourth step; a sixth step of feeding back new initial unbalanced amounts, which are obtained from said residual unbalanced amount and said initial unbalanced amounts, to said first step in the case that one or both of said residual unbalanced amounts is out of said given range; and a seventh step of machining said rotating body for correcting said dynamic unbalance in accordance with said machining amounts obtained from said fifth step and by said correcting positions determined in said first step.

In accordance with the feature of the present invention there is also provided a method of correcting the dynamic unbalance of a rotating body by either adding or subtracting corrective amounts in the axial direction of said rotating body having an unbalanced amount with respect to its axis, comprising: a first step of determining correcting positions and each corrective machining weight in accordance with information ralating to initial unbalanced amounts at two pretermined correcting planes which are axially space and passing through said rotating body; a second step of calculating the position of each center of gravity of a corrective machining portion on the assumption that corrective machining of said rotating body is effected in accordance with said correcting positions and said each corrective machining weight; a third step of calculating residual unbalanced amounts, which are located in said axial direction, from said correcting positions and said corrective machining weights; a fourth step of judging whether one or both of said residual unbalanced amounts is within a given range or not; a fifth step of calculating machining amounts corresponding to said unbalanced amounts in the case that one or both of said residual unbalanced amounts has been detected to be within said given range in said fourth step; a sixth step of feeding back newly set initial unbalanced amounts to said first step in the case that one or both of said residual unbalanced amounts is out of said predetermined range, said newly set initial unbalanced amounts being obtained by assuming two new correcting planes each including the location of said center of gravity obtained in said second step and by calculating information relating to the unbalance at the assumed planes from information relating to the location of said center of gravity of said corrective machining portions and from said initial unbalanced amounts, said information relating to unbalance at the assumed planes being converted into information relating to said newly set initial unbalanced amounts; and a seventh step of machining said rotating body for correcting said dynamic unbalance in accordance with said machining amounts obtained from said fifth step and by said correcting positions determined in said first step.

BRIEF DESCRIPTION OF THE DRAWINGS

The object and features of the present invention will become more readily apparent from the following detailed description of the preferred embodiments taken in conjunction with the accompanying drawings in which:

Figs. 1 and 2 show views of machining a rotating body by means of a milling cutter and a dril for correcting dynamic unbalance;

Fig. 3 is a flowchart showing an embodiment of the operating steps for performing the method according to the present invention;

Fig. 4 is schematic view of a rotor of an electrical motor which is an example of an objective of the method according to the present invention;

Fig. 5 is a schematic perspective view of the rotor of Fig. 4, showing various vectors used in the calculation of the method of Fig. 3;

Fig. 6 is a vector diagram showing a calculating process in the present invention method;

Fig. 7 is a partial cross-sectional view of the rotor of Figs. 4 and 5, showing the way of machining by means of a milling cutter;

Fig. 8 is a graphical representation showing the relationship between corrective weight and machining length, and between corrective weight and position of center of gravity of a removing portion;

Fig. 9 is view showing a conventional correcting method;

Fig. 10 is a graphical representation showing the relationship between the depth of drill cutting in the convenional method of Fig. 9 and corrective unbalanced amount;

Fig. 11 is a flowchart showing another embodiment of the operating steps for performing the method according to the present invention; and

Fig. 12 is a schematic perspective view of the rotor of Fig. 4, showing various vectors used in the calculation of the method of Fig. 11;

The same or corresponding elements and parts are designated at like numerals throughout the drawings.

DETAILD DESCRIPTION OF THE INVENTION

Prior to describing the embodiments of the present invention, the above-mentioned conventional method will be further discussed for better understanding of the present invention.

Fig. 9 shows a conventional method of making holes in a rotating body R in the radial directin of the rotating body R. The reference G indicates the center of gravity of removing weight of a removing portion indicated by dotted lines. The reference "r" indicates the radius of the center of gravity G. The reference G' and "r'" respectively indicate the center of gravity and the radius of the same in connection with another hole.

Fig. 10 is a graphical representation of unbalance corrective amount with respect to the depth of drill cutting. From the curve of Fig. 10, it will be understood that the unbalance corrective amount is not proportional to the depth of drill cutting when cutting hole(s) is/are made in the radial direction.

Figs. 1 and 2 respectively show other coventional methods. In Figs. 1 and 2, the references A and B respectively indicate correcting planes axially spaced and normal to the axis of the rotation of the rotor R so that the correctin planes A and B pass throuh the rotor R. The reference L indicates the distance between these two correcting planes A and B. The references UA and UB indicate removing weights corresponding to the weight of the material removed from the rotating body R by machining for neutralizing the unbalanced amounts. Fig. 1 illustrates a way of removing the material by means of a milling cutter M, while Fig. 2 illustrates a way of removing the material by means of a drill D. In both Figs. 1 and 2, the milling cutter M and the drill D are fed in a direction parallel to the axis of the rotating body R. The axis is usually included in the shaft S of the rotating body R. The center of gravity of the removed portion is indicated by the reference G in connection with the left correcting plane A, while the center of gravity of the removed portion is indicated by the reference G' in connection with the right correcting plane B.

Although the centers of gravity G and G' should be on the correcting planes A and B respectively, the positions of the centers of gravity G and G' are apt to be deviated or shifted from the correcting planes A and B due to errors. Assuming that the left center of gravity G has been deviated from the left correcting plane A by $\Delta \ell A$, residual unbalance expressed in terms of $\frac{\Delta \ell A}{L} UA$ occurs at the left correcting plane A, while another residual unbalance expressed in terms of $- \frac{\Delta \ell A}{L} UA$ occurs at the right correcting plane B. In the same manner, the deviation of the right center of gravity G' results in the occurrence of residual unbalance at the left and right correcting planes A and B. The occurrence of such residual unbalance is known as correcting plane errors. Since the amount of correction at each of the left and right correcting planes A and B affects reciprocally, recorrection of the corrective amounts has been impossible hitherto.

The present invention will be described with referene to Figs. 3 to 8 hereinbelow. Fig. 3 is a flowchart showing all the processes in a computer used for performing the method according to the present invention. Fig. 4 shows a rotating body R which is an objective of correction so that the rotating body R will be balanced. The rotating body R of Fig. 4 is a rotor of a small commutator-motor, and the rotor R has twelve slots 10 radially extending from the axis thereof. The reference numeral 11 indicates the core of the rotor R, and the correction of the dynamic unbalance of the rotor R is effected by cutting away the outer periphery of the rotor by means of a drum-shaped milling cutter 14 which is fed in the direction parallel to the axis of the rotor R. In the illustrated example, two peripheral portions 12 and 13 are simultaneously machined. The number of peripheral portions to be machined may be changed in accodance with the width of the milling cutter 14. In the above, the periphery of the drum-shaped milling cutter 14 is concaved to the outer shape of the core 11 as shown in Fig. 4.

Fig. 5 is a vector diagram showing the balancing condition of the rotor R of Fig. 4. Measured initial unbalance vectors U1 and U6 reside in end planes which are respectively expressed by Z = Z1 and Z = Z6. Corrective vectors U2, U3, U4 and U5 respectively reside in planes expressed by Z = Z2, Z = Z3, Z = Z4 and Z = Z5, where each of the planes Z = Z2, Z = Z3, Z = Z4 and Z = Z5 includes the center of gravity of each corresponding corrective weight. It is assumed that residual unbalance vectors U7 and U8 respectively reside in the planes Z = Z1 and Z = Z6 in the same manner as the initial unbalance vectors U1 and U6.

Turning back to Fig. 3, the reference 15 designates a step of inputting the initial unbalanced amounts. In this step, the initial unbalanced amounts U1 an U6, which have been measured by a conventional dynamic balance tester, are applied to a computer which is used for perfoming the method according to the present invention. Each of the unbalanced amounts U1 and U6 is expressed in terms of an unbalanced weight u1 and u6 (unit: grams) and direction θ1 and θ6 (unit: degrees) to be cut away.

A step 16 of determining the corrective angles follows the above-mentioned step 15. In this step 16, the directions of the corrective vectors U2 and U3 for correcting the initial unbalance U1, namely the directions of the core 11 to be cut away which directions are expressed in angls θ2 and θ3 (unit: degrees), are determined in such a manner that the following relationship is satisfied:

$$\theta 2 \leq \theta 1 < \theta 3 = \theta 2 + 30°$$

wherein θ2 = 0°, 30°, 60° ... 330°

The directions θ4 and θ5 of other corrective vectors U4 and U5 for correcting the other initial unbalance vector U6 are determined in the same manner as in the above.

A step 17 following the step 16 is for determining the corrective weights. In this step 17, the magnitudes u2 and u3 (unit: grams) of the corrective vectors U2 and U3 for U1 are determined by the static balancing condition at the plane Z = Z1 as shown in Fig. 6 without considering the effect of center gravity shifting. Namely, u2 and u3 are respectively given by:

$$u2 = \frac{\sin(\theta 3 - \theta 1)}{\sin(\theta 3 - \theta 2)} u1$$

$$u3 = \frac{\sin(\theta 1 - \theta 2)}{\sin(\theta 3 - \theta 2)} u1$$

The magnitudes u4 and u5 of the corrective vectors U4 and U5 for U6 are calculated in the same manne as follows:

$$u4 = \frac{\sin(\theta 5 - \theta 6)}{\sin(\theta 5 - \theta 4)} u6$$

$$u5 = \frac{\sin(\theta 6 - \theta 4)}{\sin(\theta 5 - \theta 4)} u6$$

In a following step 18 of calculating the center of gravity location, the distance Z0 between the end surface E1 of the rotor R and the center of gravity G (see Fig. 7) of the portion to be removed from the end surface E1 is obtained in connection with respective removing weights u2, u3, u4 and u5. Namely, the position of each center of gravity is obtained under an assumption that machining or cutting has been effected to remove the corrective weight u2, u3, u4 or u5. The distance between the end surface E1 and the center of gravity G2 of the removing weight u2 is expressed in terms of Z02. In the same manner, like distances Z03 to Z05 between the end surface E1 and the centers of gravity G3, G4 and G5 of the removing weights u3, u4 and u5 are obtained. From these distances Z02 to Z05, the Z ordinates of the working points of the corrective vectors U2, U3, U4 and U5 will be obtained as follows:

$$Z2 = Z1 + Z02, \qquad Z3 = Z1 + Z03$$

$$Z4 = Z6 - Z04, \qquad Z5 = Z6 - Z05$$

In the above, since it is difficult to directly obtain the positions Z0 of the centers of gravity from the removing weights "u", while it requires much time for the calculation, in practice, the value of Z0 will be approximated as follows: Namely, a plurality of corrective weights "u" corresponding to a plurality of machining or cutting lengths ℓ (see Fig. 7), and the distances Z0 indicating the position of the centers of gravity of the respective removing portions are obtained in advance. Then curves obtained from the above data will be plotted on a graph as shown in Fig. 8. From the graph of Fig 8, the corrective machining amount and the center of gravity location may be respectively expressed by way of polynominal approximations expressed in terms of $\ell = f(u)$ and $Z0 = g(u)$. The values Z0 may be obtained by substituing the values of "u" into these formulas. Alternatively, the values of "u" may be divided into a plurality of sections so that each section is represented by a corresponding formula, allowing substitution of the values of "u" to find the values of Z0.

A following step 19 is for calculating the residual unbalanced amounts U7 and U8, and in this step, residual unbalanced amounts U7 and U8, which will be left when the corrective machining is made in accordance with the data determined by the steps 16, 17 and 18, are derived from a formula of dynamic balance. The condition for the dynamic balance of the rotor shown in Fig. 5 is that the following two equations are fulfilled, representing the residual unbalanced amounts by U7 and U8.

$$\text{Resultant unbalance} = U1 - U2 - U3 - U4 - U5 + U6 - U7 - U8 = 0$$

$$\text{Resultant moment} = Z1U1 - Z2U2 - Z3U3 - Z4U4 - Z5U5 + Z6U6 - Z1U7 - Z6U8 = 0$$

From the above formula of resultant unbalance, a relationship of U7 = −U8 is derived, and this relationship is substituted in the formula of resultant moment to obtain U8 as follows:

$$U8 = \frac{1}{Z6 - Z1}\,(Z1U2-Z2U2-Z3U3-Z4U4-Z5U5+Z6U6)$$

The values of the residual unbalanced amounts U7 and U8 are respectively obtained from the above operations. In actual vector calculation, the vector components may be divided into "x" component and "y" component. In the above formula for obtaining the residual unbalanced amounts, initial unbalanced amounts, which have been actually measured, are used as the values of U1 and U6. Namely, substituted U1' and U6' obtained in a new-initial unbalanced amounts determining step 23 of Fig. 3 are not used for these values.

In a step 20 of judging, which follows the step 19, it is detected whether the absolute values |U7| and |U8| of the residual unbalanced amounts U7 and U8 are smaller than their tolerances or not. If the absolute values are within the tolerances, a following step 21 for calculating machining length will takes place because the unbalanced amounts are negligibly small. In the step 21, machining lengths $\ell 2$, $\ell 3$, $\ell 4$, and $\ell 5$ respectively corresponding to corrective weights u2, u3, u4 and u5 are calculated by the formula of $\ell = f(u)$ described in connection with the step 18 for caculating the position of center of gravity.

After the step 21, a machining data emitting step 22 will take place. In this step 22, $\theta 2$, $\theta 3$, $\theta 4$, $\theta 5$, $\ell 2$, $\ell 3$, $\ell 4$ and $\ell 5$ will be emitted from the computer as machining data, completing all the calculations.

If the condition in the judging step 20 is not fulfilled, the step 23 is executed in place of the step 21. The step 23 is for determining new initial unbalanced amounts U1' and U6' by adding the residual unbalanced amounts U7 and U8 to the initial unbalanced amounts U1 and U6 as follows:

$$U1' = U1 + \alpha U7$$

$$U6' = U6 + \alpha U8$$

In the above, α is a costant for speeding up the convergence of the solution. The data U1' and U6' obtained in the step 23 are returned to the correcting angle determining step 16, so that U1 and U6 will be substituted with U1' and U6'. The steps from 16 to 20 are executed in the same manner as described in the above using U1' and U6'. Calculations in the steps 16 to 19 will be repeated until the condition of the judging step 20 is fulfilled. As a result, machining data which satisfies the condition of the step 20 will be finally emitted in the step 22.

In the above-described embodiment, although the correcting planes Z = Z1 and Z = Z6 are respevctively set at the both end surfaces E1 and E2 of the rotor R, these correcting planes may be set arbitrarily. Furthermore, although it has been described that correction of the dynamic unbalance is perfectly effected at two planes, it is possible to leave a given amount of residual unbalance on purpose by adjusting the amount of corrective machining if desired.

The residual unbalanced amounts may be obtained in a different way from the above-described one. According to this method, which may constitute a modification of the above desribed first embodiment, the two formulas relating to the balancing condition, which are described in connection with the residual unbalanced amount calculating step 19, are not used. Namely, residual unbalanced amounts at the planes A and B of Fig. 1 will be obtained as follows based on the fact that the corrective amount UA at the plane A results in the occurrence of residual unbalance of $\frac{\Delta \ell A}{L}UA$ and $-\frac{\Delta \ell A}{L}UA$ at the planes A and B, while the corrective amount UB at the plane B results in the occurrence of residual unbalance of $-\frac{\Delta \ell B}{L}UB$ and $\frac{\Delta \ell B}{L}UB$ at the planes A and B:

$$UA' = UA + \frac{\Delta \ell A}{L}UA - \frac{\Delta \ell B}{L}UB$$

$$UB' = UB - \frac{\Delta \ell A}{L}UA + \frac{\Delta \ell B}{L}UB$$

Therefore, by effecting corrective machining corresponding to U'A and U'B in place of effecting corrective machining corresponding to UA and UB, it is possible to modify the amount of corrective machining. This substantially corresponds to performing feedback of the amount of residual unbalance once in the caculating process of Fig. 1.

Furthermore, although the first embodiment has been described in connection with a case of two components of force of each correcting plane whose corrective machining position has been limited, similar calculating processes may be applied to other cases, such as a case that the corrective machining direction is not limited, a case that no component of force is required or a case of more than two components of force. In the first embodiment, the shifting of the center of gravity of the corrective weight portion in the direction Z by milling cutter machining is taken into account as shown in Fig. 7, while slight shifting Δr of the center of gravity in the radial direction shown in Fig. 1 has been ignored. However, the value of Δr may be obtained by adding calulation to calculating step 18 of Fig. 3, so that this component may be included by substituting the same by using $(1+ \frac{\Delta r}{r})u$ in place of "u" in the step of calculating the residual unbalanced amounts.

Another modification or emobidment will be described with reference to Figs. 11 and 12. Fig. 11 is a flowchart, and in this flowchart, a step 15 of inputting initial unbalanced amounts, a step 16 of determining corrective angles and a step 17 of determining corrective weights are performed in the same manner as in the above-described embodiment. However, the step 18 of caculating the locations of centers of gravity is changed as follows: Namely, in addition to the caculation of the step 18 of Fig. 3, the step 18' of Fig. 11 comprises calculating steps for obtaining centers of gravity Z1' and Z6' which are respectively imagined as the resultant centers of gravity between the two vectors U2 and U3 and between the other two vectors U4 and U5. In detail, the positions Z1' AND Z6' of the resultant centers of gravity U2 and U3 will be given by:

$$Z1' = \frac{u2Z2 + u3Z3}{u2 + u3}$$

$$Z6' = \frac{u4Z4 + u5Z5}{u4 + u5}$$

The following step 19 of calculating residual unbalanced amounts, the step 20 of judging, the step 21 of calculating machining lengths and the step 22 of emitting machining data are the same as in the flowchart of Fig. 3. The new initial unbalanced amounts determining step 23 of Fig. 3 is replaced with a correcting plane converting step 23' in Fig. 11. In this step 23', the initial unbalanced amounts U1(u1, θ1) and U6(u6, θ6) at the predetermined correcting planes Z = Z1 and Z = Z6 are converted into initial unbalanced amounts U1"(u1", θ1") and U6(u6", θ6") at Z ordinates Z = Z1' and Z = Z6' which have been obtained in the step 18' of calculating center of gravity positions. Formulas for effecting this conversion are also derived from the formulas of dynamic balance. According to these formulas:

Resultant unbalance = U1 + U6 = U1" + U6"

Resultant moment = Z1U1 + Z6U6 = Z1'U1" + Z6'U6"

From these formulas U1" and U6" are given by:

$$U1'' = \frac{(Z6' - Z1)U1 - (Z6 - Z6')U6}{Z6' - Z1'}$$

$$U6'' = \frac{-(Z1' - Z1)U1 + (Z6 - Z1')U6}{Z6' - Z1'}$$

Then the values of U1" and U6" are returned or fed back to the step 16 of determining correcting angles so that U1 and U6 will be replaced. The following calculating steps are repeated so that each of the correcting planes at the time of indicating dynamic unbalance will closely aproach the position of the center of gravity of the corrective machining portion. As a result, it is possible to cancel so called correcting plane errors, and therefore, machining data fulfilling the conditin of the judging step 20 will be emitted.

In the above-described embodiments of the present invention, the rotor is machined by means of a milling cuter, drill or the like so as to remove a given amount or weight therefrom. However, in place of removing a corrective amount or weight, a corresponding corrective amount may be added to the rotor. For instance, sevral holes may be made axially in the rotor in advance, and corrective weights may be filled in some of these holes to offset the unbalance.

From the foregoing description, it will be understood that the solution for the corrective machining amounts, which provides dynamic balance of a rotating body, can be obtained by performing operations in a computer in a correcting apparatus in such a manner that measurement and corrective machining are repeatedly simulated. Consequently, the solution, which has been difficult to obtain with a high acuracy hitherto, can be found with relatively simple steps, while the accuracy of the solution is sufficiently high in practical use. According to the present invention, since there is no need to repeat measurments and machinings because high accuracy in balance can be obtained by maching the rotating body once, the cost required for balancing work can be reduced, while the cost of an automatic correcting apparatus can also be reduced. The above-described embodiments are just examples of the present invention, and therefore, it will be apparent for those skilled in the are that many modifications and variations may be made without departing from the spirit of the present invention.

~~WHAT IS CLAIMED IS:~~ CLAIMS

1. A method of correcting the dynamic unbalance of a rotating body by either adding or subtracting corrective amounts in the axial direction of said rotating body having an unbalanced amount with respect to its axis, comprising:

(a) a first step of determining correcting positions and corrective machining weights in accordance with information ralating to initial unbalanced amounts at two predetermined correcting planes which are axially spaced and passing through said rotating body;

(b) a second step of calculating the position of center of gravity of each corrective machining portion on the assumption that corrective machining of said rotating body is effected in accordance with said correcting positions and said corective machining weights;

(c) a third step of calculating residual unbalanced amounts, which are located in said axial direction, from said correcting positions and said corrective machining weights;

(d) a fourth step of judging whether one or both of said residual unbalanced amounts is within a given range or not;

(e) a fifth step of calculating machining amounts corresponding to said unbalanced amounts in the case that one or both of said residual unbalanced amounts has been detected to be within said given range in said fourth step;

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(f) a sixth step of feeding back new initial unbalanced amounts, which are obtained from said residual unbalanced amount and said initial unbalanced amounts, to said first step in the case that one or both of said residual unbalanced amounts is out of said given range; and

(g) a seventh step of machining said rotating body for correcting said dynamic unbalance in accordance with said machining amounts obtained from said fifth step and by said correcting positions determined in said first step.

2. A method of correcting the dynamic unbalance of a rotating body by either adding or subtracting corrective amounts in the axial direction of said rotating body having an unbalanced amount with respect to its axis, comprising:

(a) a first step of determining correcting positions and each corrective machining weight in accordance with information ralating to initial unbalanced amounts at two pretermined correcting planes which are axially space and passing through said rotating body;

(b) a second step of calculating the position of each center of gravity of a corrective machining portion on the assumption that corrective machining of said rotating body is effected in accordance with said correcting positions and said each corrective machining weight;

(c) a third step of calculating residual unbalanced amounts, which are located in said axial direction, from said correcting positions and said corrective machining weights;

(d) a fourth step of judging whether one or both of said residual unbalanced amounts is within a given range or not;

(e) a fifth step of calculating machining amounts corresponding to said unbalanced amounts in the case that one or both of said residual unbalanced amounts has been detected to be within said given range in said fourth step;

(f) a sixth step of feeding back newly set initial unbalanced amounts to said first step in the case that one or both of said residual unbalanced amounts is out of said predetermined range, said newly set initial unbalanced amounts being obtained by assuming two new correcting planes each including the location of said center of gravity obtained in said second step and by calculating information relating to the unbalance at the assumed planes from information relating to the location of said center of gravity of said corrective machining portions and from said initial unbalanced amounts, said information relating to unbalance at the assumed planes being converted into information relating to said newly set initial unbalanced amounts; and

(g) a seventh step of machining said rotating body for correcting said dynamic unbalance in accordance with said machining amounts obtained from said fifth step and by said correcting positions determined in said first step.

3. A method of correcting the dynamic unbalance of a rotating body as claimed in Claim 1 or 2, wherein said correcting positions are located along the circumference of said rotating body at a given angle interval.

4. A method of correcting the dynamic unbalance of a rotating body as claimed in Claim 3, wherein each of vectors indicative of said initial unbalanced amounts is relolved into a plurality of vectors located at said correcting positions which are located with given angles so that said correcting positions and said corrective machining weights are respectively found.

5. A method of correcting the dynamic unbalance of a rotating body as claimed in Claim 1, wherein each said new initial unbalanced amounts is obtained by adding a function of said residual unbalanced amount to said initial unbalanced amount.

6. A method of correcting the dynamic unbalance of a rotating body as claimed in Claim 2, wherein said second step comprises a step of calculating the location of each resultant center of gravity of two adacent corrective vectors which are vector components of each of said initial unbalanced amounts.

FIG. 1

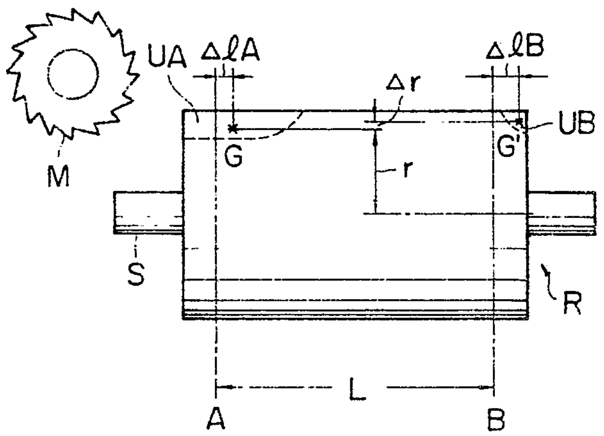

FIG. 2

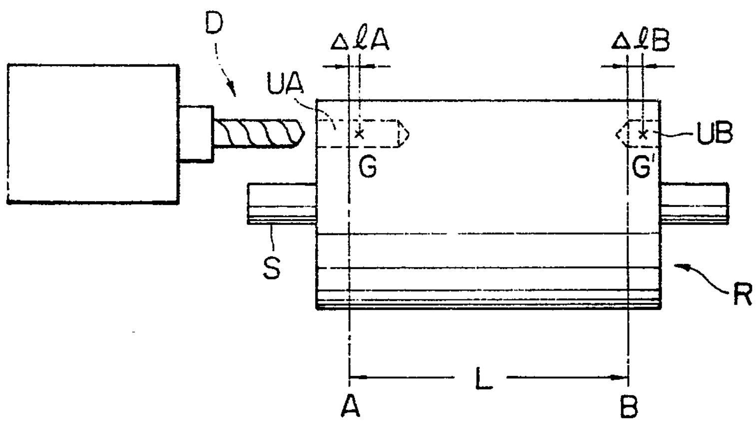

FIG. 3

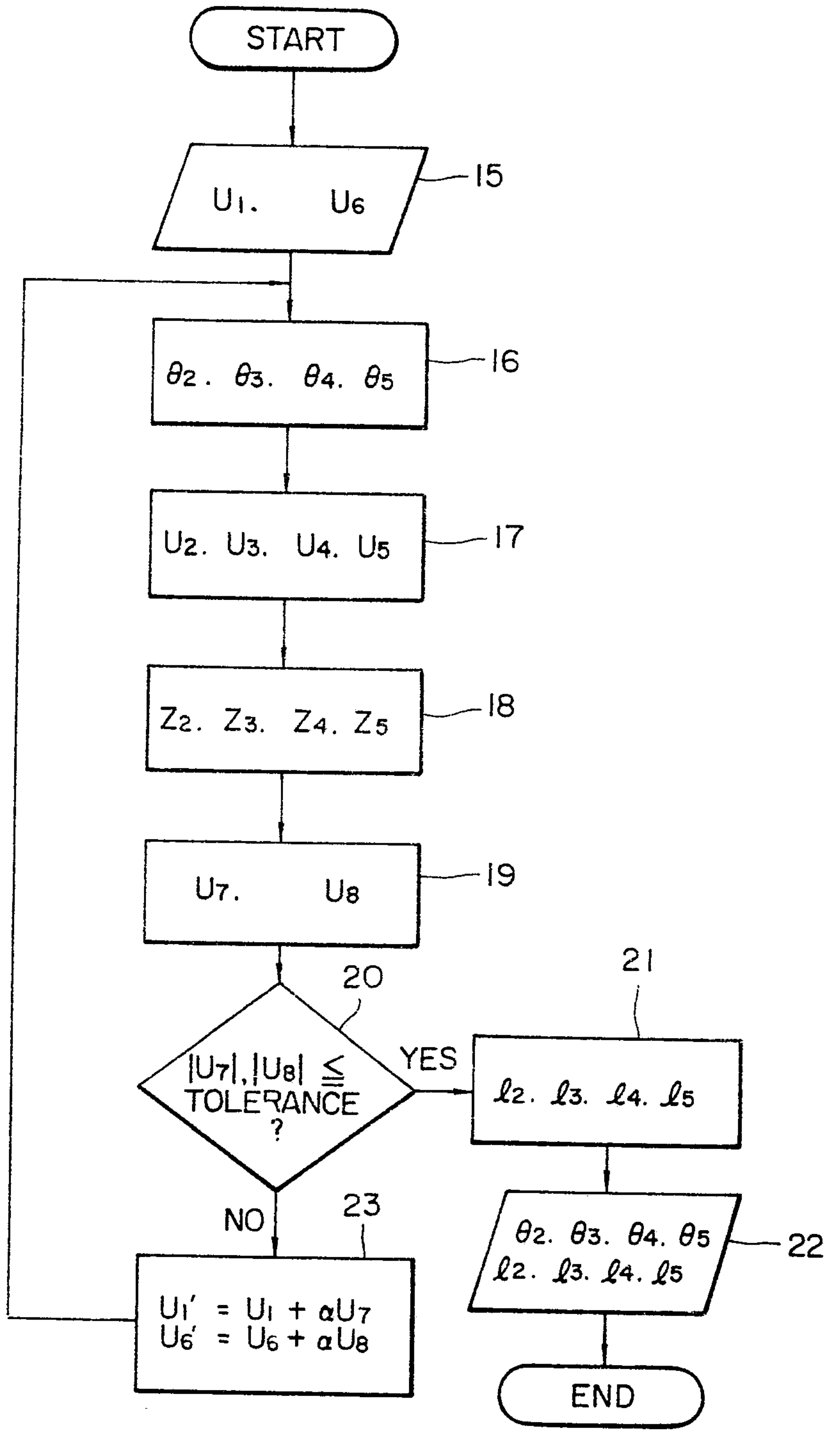
START
U1. U6
15
θ2. θ3. θ4. θ5
16
U2. U3. U4. U5
17
Z2. Z3. Z4. Z5
18
U7. U8
19
20
|U7|, |U8| ≦ TOLERANCE ?
YES
NO
21
ℓ2. ℓ3. ℓ4. ℓ5
θ2. θ3. θ4. θ5
ℓ2. ℓ3. ℓ4. ℓ5
22
23
U1' = U1 + αU7
U6' = U6 + αU8
END

FIG. 4

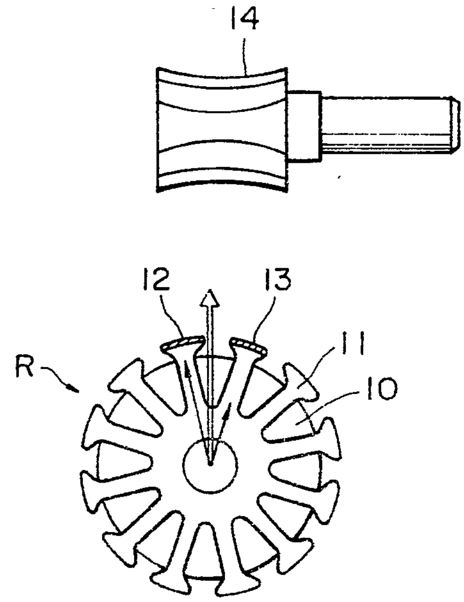

FIG. 5

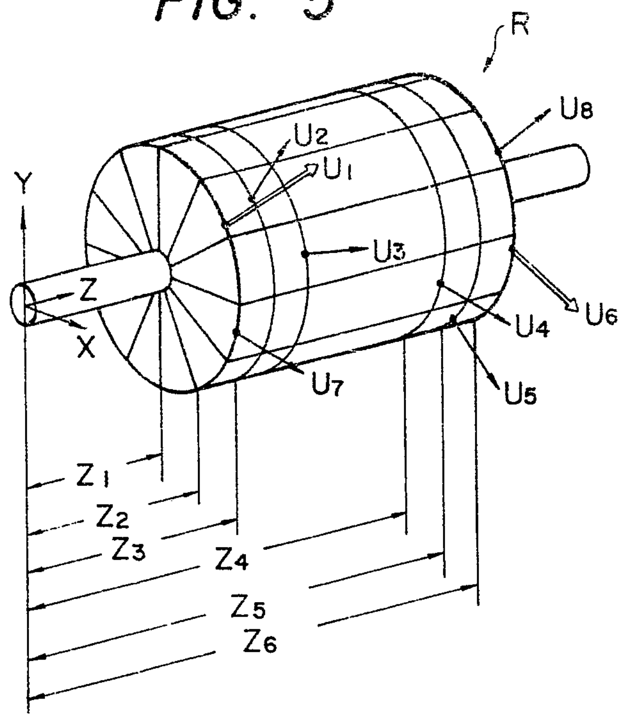

FIG. 6

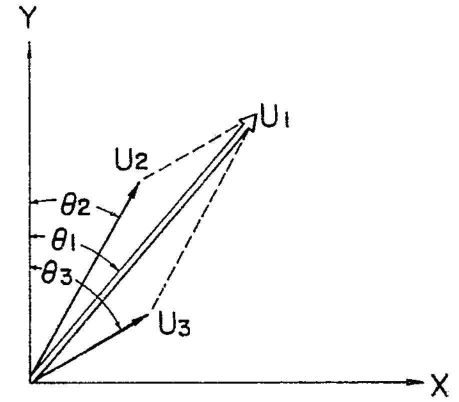

FIG. 7

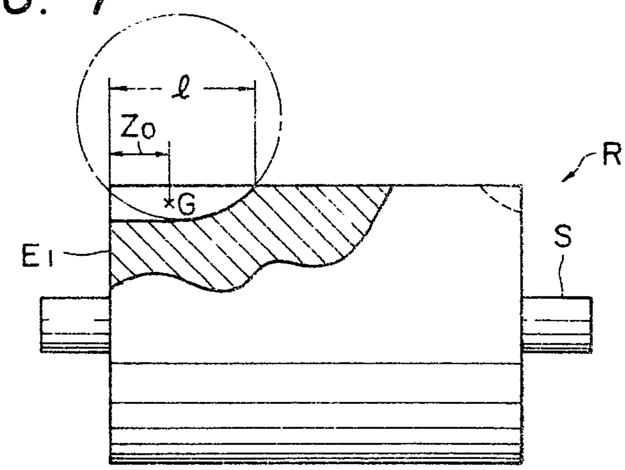

FIG. 8

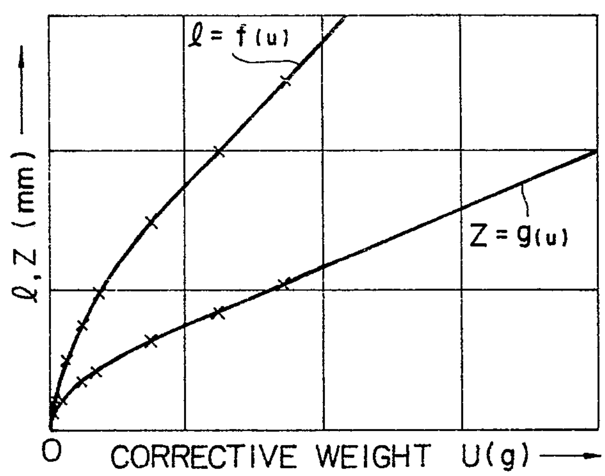

FIG. 9 PRIOR ART

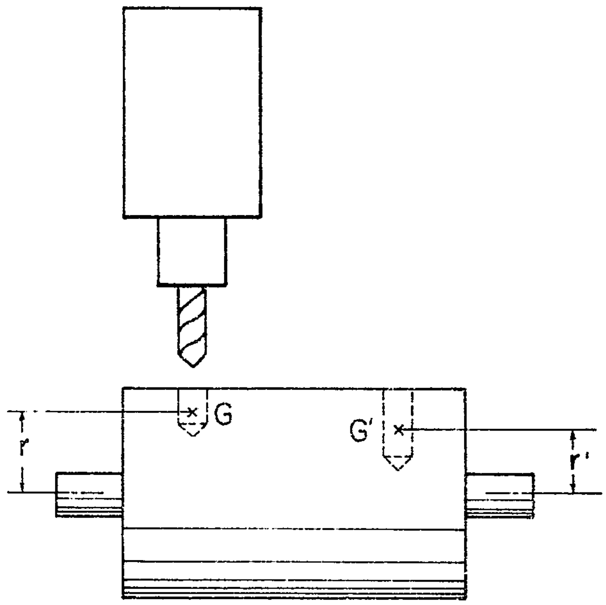

FIG. 10 PRIOR ART

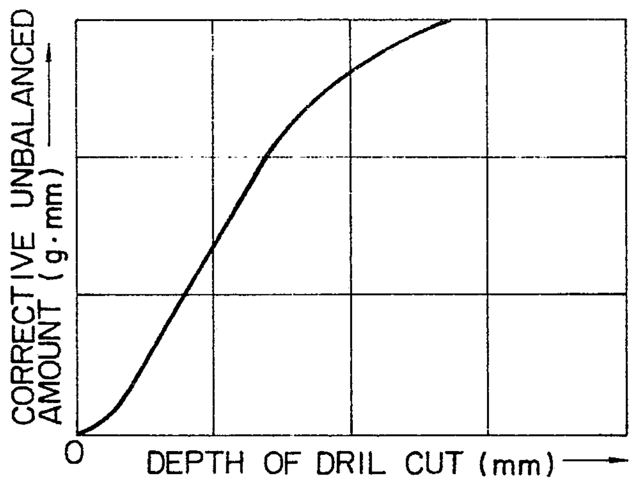

FIG. 11

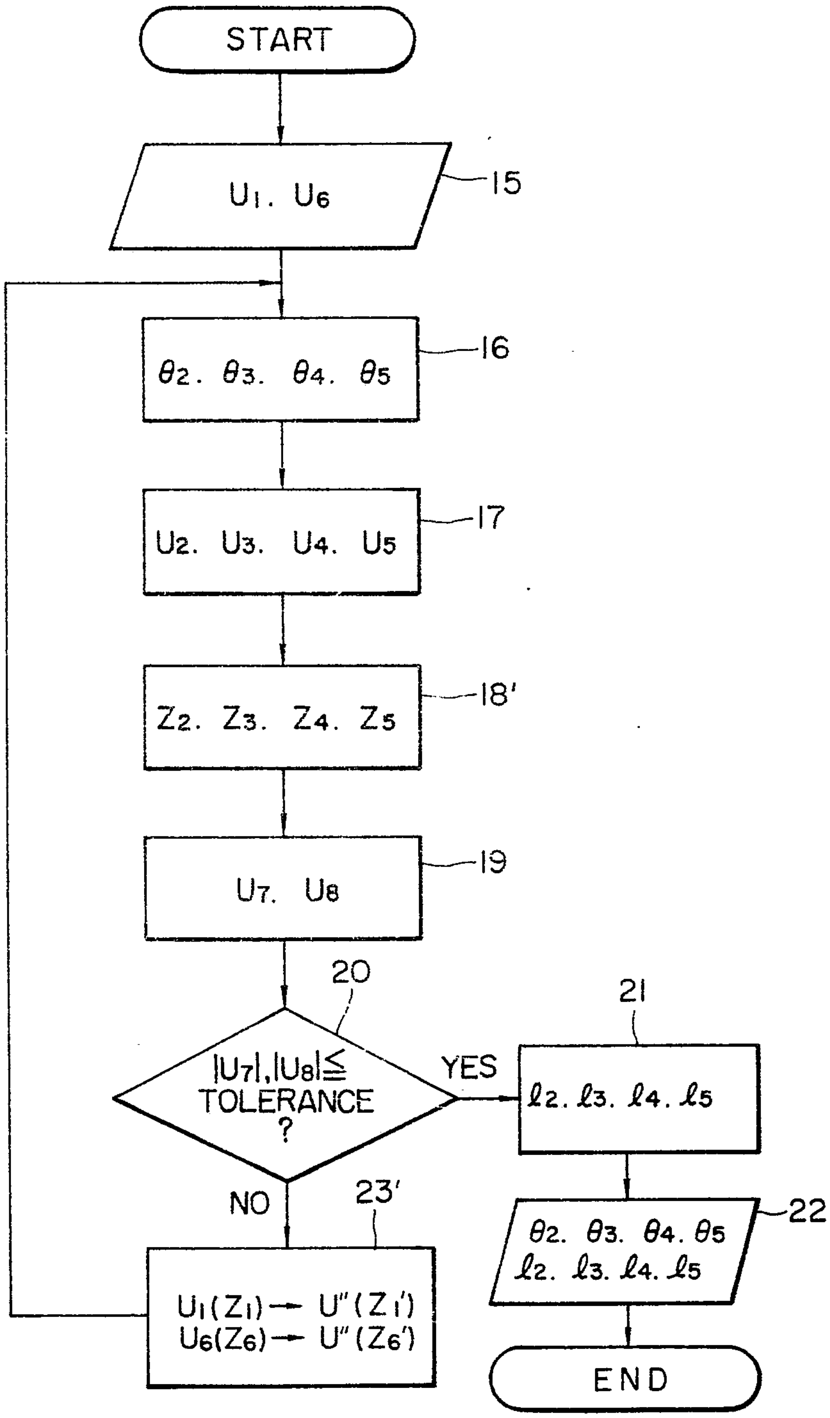
START
U1. U6
15
θ2. θ3. θ4. θ5
16
U2. U3. U4. U5
17
Z2. Z3. Z4. Z5
18'
U7. U8
19
20
|U7|,|U8|≦ TOLERANCE ?
YES
NO
21
ℓ2. ℓ3. ℓ4. ℓ5
22
θ2. θ3. θ4. θ5
ℓ2. ℓ3. ℓ4. ℓ5
END
23'
U1(Z1) → U''(Z1')
U6(Z6) → U''(Z6')

FIG. 12